



Common Market for Eastern and Southern Africa



EDICT OF GOVERNMENT



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COMESA 225-1 (2006) (English/French):
Polyvinyl chloride insulated cables of rated
voltages up to and including 450/750 V - Part
1: General requirements



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COMESA HARMONISED
STANDARD

COMESA/DHS
DHS 225-1: 2005

**Polyvinyl chloride insulated cables of rated
voltages up to and including 450/750 V - Part
1: General requirements**

REFERENCE: DHS 225-1: 2005

Foreword

The Common Market for Eastern and Southern Africa (COMESA) was established in 1994 as a regional economic grouping consisting of 20 member states after signing the co-operation Treaty. In Chapter 15 of the COMESA Treaty, Member States agreed to co-operate on matters of standardisation and Quality assurance with the aim of facilitating the faster movement of goods and services within the region so as to enhance expansion of intra-COMESA trade and industrial expansion.

Co-operation in standardisation is expected to result into having uniformly harmonised standards. Harmonisation of standards within the region is expected to reduce Technical Barriers to Trade that are normally encountered when goods and services are exchanged between COMESA Member States due to differences in technical requirements. Harmonized COMESA Standards are also expected to result into benefits such as greater industrial productivity and competitiveness, increased agricultural production and food security, a more rational exploitation of natural resources among others.

COMESA Standards are developed by the COMESA experts on standards representing the National Standards Bodies and other stakeholders within the region in accordance with international procedures and practices. Standards are approved by circulating Final Draft Harmonized Standards (FDHS) to all member states for a one Month vote. The assumption is that all contentious issues would have been resolved during the previous stages or that an international or regional standard being adopted has been subjected through a development process consistent with accepted international practice.

COMESA Standards are subject to review, to keep pace with technological advances. Users of the COMESA Harmonized Standards are therefore expected to ensure that they always have the latest version of the standards they are implementing.

This COMESA standard is technically identical to the International Standard *IEC 60227-1:1998*.

<p>A COMESA Harmonized Standard does not purport to include all necessary provisions of a contract. Users are responsible for its correct application.</p>
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**NORME
INTERNATIONALE
INTERNATIONAL
STANDARD**

**CEI
IEC**

60227-1

Edition 2.2

1998-03

Edition 2:1993 consolidée par les amendements 1:1995 et 2:1997
Edition 2:1993 consolidated with amendments 1:1995 and 2:1997

**Conducteurs et câbles isolés au polychlorure
de vinyle, de tension nominale au plus égale
à 450/750 V –**

**Partie 1:
Prescriptions générales**

**Polyvinyl chloride insulated cables
of rated voltages up to and including
450/750 V –**

**Part 1:
General requirements**



Numéro de référence
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Numéros des publications

Depuis le 1er janvier 1997, les publications de la CEI sont numérotées à partir de 60000.

Publications consolidées

Les versions consolidées de certaines publications de la CEI incorporant les amendements sont disponibles. Par exemple, les numéros d'édition 1.0, 1.1 et 1.2 indiquent respectivement la publication de base, la publication de base incorporant l'amendement 1, et la publication de base incorporant les amendements 1 et 2.

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Le contenu technique des publications de la CEI est constamment revu par la CEI afin qu'il reflète l'état actuel de la technique.

Des renseignements relatifs à la date de reconfirmation de la publication sont disponibles dans le Catalogue de la CEI.

Les renseignements relatifs à ces révisions, à l'établissement des éditions révisées et aux amendements peuvent être obtenus auprès des Comités nationaux de la CEI et dans les documents ci-dessous:

- **Bulletin de la CEI**
- **Annuaire de la CEI**
Accès en ligne*
- **Catalogue des publications de la CEI**
Publié annuellement et mis à jour régulièrement (Accès en ligne)*

Terminologie, symboles graphiques et littéraux

En ce qui concerne la terminologie générale, le lecteur se reportera à la CEI 60050: *Vocabulaire Electrotechnique International* (VEI).

Pour les symboles graphiques, les symboles littéraux et les signes d'usage général approuvés par la CEI, le lecteur consultera la CEI 60027: *Symboles littéraux à utiliser en électrotechnique*, la CEI 60417: *Symboles graphiques utilisables sur le matériel. Index, relevé et compilation des feuilles individuelles*, et la CEI 60617: *Symboles graphiques pour schémas*.

Publications de la CEI établies par le même comité d'études

L'attention du lecteur est attirée sur les listes figurant à la fin de cette publication, qui énumèrent les publications de la CEI préparées par le comité d'études qui a établi la présente publication.

* Voir adresse «site web» sur la page de titre.

Numbering

As from 1 January 1997 all IEC publications are issued with a designation in the 60000 series.

Consolidated publications

Consolidated versions of some IEC publications including amendments are available. For example, edition numbers 1.0, 1.1 and 1.2 refer, respectively, to the base publication, the base publication incorporating amendment 1 and the base publication incorporating amendments 1 and 2.

Validity of this publication

The technical content of IEC publications is kept under constant review by the IEC, thus ensuring that the content reflects current technology.

Information relating to the date of the reconfirmation of the publication is available in the IEC catalogue.

Information on the revision work, the issue of revised editions and amendments may be obtained from IEC National Committees and from the following IEC sources:

- **IEC Bulletin**
- **IEC Yearbook**
On-line access*
- **Catalogue of IEC publications**
Published yearly with regular updates (On-line access)*

Terminology, graphical and letter symbols

For general terminology, readers are referred to IEC 60050: *International Electrotechnical Vocabulary* (IEV).

For graphical symbols, and letter symbols and signs approved by the IEC for general use, readers are referred to publications IEC 60027: *Letter symbols to be used in electrical technology*, IEC 60417: *Graphical symbols for use on equipment. Index, survey and compilation of the single sheets* and IEC 60617: *Graphical symbols for diagrams*.

IEC publications prepared by the same technical committee

The attention of readers is drawn to the end pages of this publication which list the IEC publications issued by the technical committee which has prepared the present publication.

* See web site address on title page.

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Commission Electrotechnique Internationale
International Electrotechnical Commission
Международная Электротехническая Комиссия

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For price, see current catalogue*

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

POLYVINYL CHLORIDE INSULATED CABLES OF RATED VOLTAGES UP TO AND INCLUDING 450/750 V

Part 1: General requirements

FOREWORD

- 1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of the IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested National Committees.
- 3) The documents produced have the form of recommendations for international use and are published in the form of standards, technical reports or guides and they are accepted by the National Committees in that sense.
- 4) In order to promote international unification, IEC National Committees undertake to apply IEC International Standards transparently to the maximum extent possible in their national and regional standards. Any divergence between the IEC Standard and the corresponding national or regional standard shall be clearly indicated in the latter.
- 5) The IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with one of its standards.
- 6) Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. The IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 60227-1 has been prepared by subcommittee 20B: Low-voltage cables, of IEC technical committee 20: Electric cables.

This consolidated version of IEC 60227-1 is based on the second edition (1993) [documents 20(CO)115 and 20B(CO)124], its amendment 1 (1995) [documents 20B/184/FDIS and 20B/197/RVD] and amendment 2 (1997) [documents 20B/254/FDIS and 20B/262/RVD].

It bears the edition number 2.2.

A vertical line shows where the base publication has been modified by amendments 1 and 2.

IEC 60227 consists of the following parts, under the general title: Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V:

Part 1: General requirements

Part 2: Test methods

Part 3: Non-sheathed cables for fixed wiring

Part 4: Sheathed cables for fixed wiring

Part 5: Flexible cables (cords)

Part 6: Lift cables and cables for flexible connections.

Part 3, Part 4, etc. are for particular types of cable and should be read in conjunction with Part 1 and Part 2. Further parts may be added as other types are standardized.

Annex A forms an integral part of this International Standard.

POLYVINYL CHLORIDE INSULATED CABLES OF RATED VOLTAGES UP TO AND INCLUDING 450/750 V

Part 1: General requirements

1 General

1.1 Scope

This part of International Standard IEC 60227 applies to rigid and flexible cables with insulation, and sheath if any, based on polyvinyl chloride, of rated voltages U_0/U up to and including 450/750 V used in power installations of nominal voltage not exceeding 450/750 V a.c.

NOTE – For some types of flexible cables the term cord is used.

The particular types of cables are specified in IEC 60227-3, IEC 60227-4, etc. The code designations of these types of cables are given in annex A.

The test methods specified in Parts 1, 3, 4, etc. are given in IEC 60227-2, IEC 60332-1 and in the relevant parts of IEC 60811.

1.2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 60227. At the time of publication, the editions indicated were valid. All normative documents are subject to revision and parties to agreements based on this part of IEC 60227 are encouraged to investigate the possibility of applying the most recent editions of the normative documents listed below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60173:1964, *Colours of the cores of flexible cables and cords*

IEC 60227-2:1979, *Polyvinyl chloride insulated cables of rated voltage up to and including 450/750 V – Part 2: Test methods*

IEC 60227-3:1979, *Polyvinyl chloride insulated cables of rated voltage up to and including 450/750 V – Part 3: Non-sheathed cables for fixed wiring*

IEC 60227-4:1979, *Polyvinyl chloride insulated cables of rated voltage up to and including 450/750 V – Part 4: Sheathed cables for fixed wiring*

IEC 60228:1978, *Conductors of insulated cables*

IEC 60332-1:1979, *Tests on electric cables under fire conditions – Part 1: Test on a single vertical insulated wire or cable*

IEC 60811-1-1:1985, *Common test methods for insulating and sheathing materials of electric cables – Part 1: Methods for general application – Section One: Measuring of thickness and overall dimensions – Tests for determining the mechanical properties*
Amendment 1 (1988). Amendment 2 (1989)

IEC 60811-1-2:1985, *Common test methods for insulating and sheathing materials of electric cables – Part 1: Methods for general application – Section Two: Thermal ageing methods*
Amendment 1 (1989)

IEC 60811-1-4:1985, *Common test methods for insulating and sheathing materials of electric cables – Part 1: Methods for general application – Section Four: Tests at low temperature*

IEC 60811-3-1:1985, *Common test methods for insulating and sheathing materials of electric cables – Part 3: Methods specific to PVC compounds – Section One: Pressure test at high temperature – Tests for resistance to cracking*

IEC 60811-3-2:1985, *Common test methods for insulating and sheathing materials of electric cables – Part 3: Methods specific to PVC compounds – Section Two: Loss of mass test – Thermal stability tests*

2 Definitions

For the purpose of this standard the following definitions shall apply.

2.1 Definitions relating to insulating and sheathing materials

2.1.1 Polyvinyl chloride compound (PVC)

Combination of materials suitably selected, proportioned and treated, of which the characteristic constituent is the plastomer polyvinyl chloride or one of its copolymers. The same term also designates compounds containing both polyvinyl chloride and certain of its polymers.

2.1.2 Type of compound

The category in which a compound is placed according to its properties, as determined by specific tests. The type designation is not directly related to the composition of the compound.

2.2 Definitions relating to the tests

2.2.1 Type tests (symbol *T*)

Tests required to be made before supplying a type of cable covered by this standard on a general commercial basis in order to demonstrate satisfactory performance characteristics to meet the intended application. These tests are of such a nature that, after they have been made, they need not be repeated unless changes are made in the cable materials or design which might change the performance characteristics.

2.2.2 Sample tests (symbol S)

Tests made on samples of completed cable or components taken from a completed cable, adequate to verify that the finished product meets the design specifications.

2.3 Rated voltage

The rated voltage of a cable is the reference voltage for which the cable is designed and which serves to define the electrical tests.

The rated voltage is expressed by the combination of two values U_0/U , expressed in volts:

U_0 being the r.m.s. value between any insulated conductor and "earth" (metal covering of the cable or the surrounding medium);

U being the r.m.s. value between any two-phase conductors of a multicore cable or of a system of single-core cables.

In an alternating current system, the rated voltage of a cable shall be at least equal to the nominal voltage of the system for which it is intended.

This condition applies both to the value U_0 and to the value U .

In a direct current system, the nominal voltage of the system shall be not higher than 1,5 times the rated voltage of the cable.

NOTE – The operating voltage of a system may permanently exceed the nominal voltage of such a system by 10 %. A cable can be used at a 10 % higher operating voltage than its rated voltage if the latter is at least equal to the nominal voltage of the system.

3 Marking

3.1 Indication of origin and cable identification

Cables shall be provided with an indication of the manufacturer, which shall be either an identification thread or a repetitive marking of the manufacturer's name or trade-mark.

Cables for use at a conductor temperature exceeding 70 °C shall also be marked either with the code designation or with the maximum conductor temperature.

Marking may be by printing or by reproduction in relief on or in the insulation or sheath.

3.1.1 Continuity of marks

Each specified mark shall be regarded as continuous if the distance between the end of the mark and the beginning of the next identical mark does not exceed

- 550 mm if the marking is on the outer sheath of the cable;
- 275 mm if the marking is
 - a) on the insulation of an unsheathed cable;
 - b) on the insulation of a sheathed cable;
 - c) on a tape within a sheathed cable.

3.2 Durability

Printed markings shall be durable. Compliance with this requirement shall be checked by the test given in 1.8 of IEC 60227-2.

3.3 Legibility

All markings shall be legible.

The colours of the identification threads shall be easy to recognize or easily made recognizable, if necessary, by cleaning with petrol or other suitable solvent.

4 Core identification

Each core shall be identified as follows:

- in cables having up to and including five cores by colour, see 4.1;
- in cables having more than five cores by number, see 4.2.

NOTE – The colour scheme, and in particular the scheme for rigid multicore cables, is under consideration.

4.1 Core identification by colours

4.1.1 General requirements

Identification of the cores of a cable shall be achieved by the use of coloured insulation or other suitable method.

Each core of a cable shall have only one colour, except the core identified by a combination of the colours green-and-yellow.

The colours red, grey, white and, when not in combination, green and yellow, shall not be used for any multicore cable.

4.1.2 Colour scheme

The preferred colour scheme for flexible cables and single-core cables is:

- single-core cable: no preferred colour scheme;
- two-core cable: no preferred colour scheme;

NOTE – It is not necessary to identify the cores of non-sheathed flat two-core cords.

- three-core cable: either green-and-yellow, light blue, brown,
or light blue, black, brown;
- four-core cable: either green-and-yellow, light blue, black, brown,
or light blue, black, brown, black or brown;
- five-core cable: either green-and-yellow, light blue, black, brown, black or
brown, or light blue, black, brown, black or brown, black or
brown.

The colours shall be clearly identifiable and durable. Durability shall be checked by the test given in 1.8 of IEC 60227-2.

4.1.3 Colour combination green-and-yellow

The distribution of the colours for the core coloured green-and-yellow shall comply with the following condition (which is in accordance with IEC 60173): for every 15 mm length of core, one of these colours shall cover at least 30 % and not more than 70 % of the surface of the core, the other colour covering the remainder.

NOTE – Information on the use of the colours green-and-yellow and light blue.

It is understood that the colours green and yellow, when they are combined as specified above, are recognized exclusively as a means of identification of the core intended for use as earth connection or similar protection, and that the colour light blue is intended for the identification of the core intended to be connected to neutral. If, however, there is no neutral, light blue can be used to identify any core except the earthing or protective conductor.

4.2 Core identification by numbers

4.2.1 General requirements

The insulation of the cores shall be of the same colour and numbered sequentially, except for the core coloured green-and-yellow, if one is included.

The green-and-yellow core, if any, shall comply with the requirement of 4.1.3 and shall be in the outer layer.

The numbering shall start by number 1 in the inner layer.

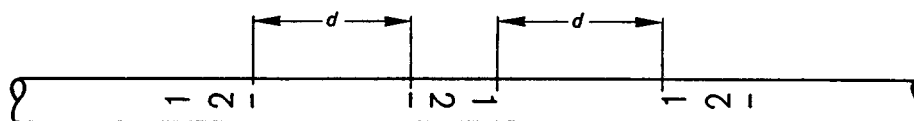
The numbers shall be printed in arabic numerals on the outer surfaces of the cores. All the numbers shall be of the same colour, which shall contrast with the colour of the insulation. The numerals shall be legible.

4.2.2 Preferred arrangement of marking

The numbers shall be repeated, at regular intervals along the core, consecutive numbers being inverted in relation to each other.

When the number is a single numeral, a dash shall be placed underneath it. If the number consists of two numerals, these shall be disposed one below the other and a dash placed below the lower numeral. The spacing d between consecutive numbers shall not exceed 50 mm.

The arrangement of the marks is shown in the figure below.



4.2.3 Durability

Printed numerals shall be durable. Compliance with this requirement shall be checked by the test given in 1.8 of IEC 60227-2.

5 General requirements for the construction of cables

5.1 Conductors

5.1.1 Material

The conductors shall consist of annealed copper, except for the wires of tinsel cords, for which a copper alloy may be used. The wires may be plain or tinned.

5.1.2 Construction

The maximum diameters of the wires of flexible conductors – other than the conductors of tinsel cords – and the minimum number of the wires of rigid conductors shall be in accordance with IEC 60228.

The classes of the conductors relevant to the various types of cables are given in the particular specifications (see IEC 60227-3, IEC 60227-4, etc.).

Conductors of cables for fixed installations shall be circular solid, circular stranded or compacted circular stranded conductors.

For tinsel cords each conductor shall comprise a number of strands or groups of strands, twisted together, each strand being composed of one or more flattened wires of copper or copper alloy, helically wound on a thread of cotton, polyamide or similar material.

5.1.3 Check on construction

Compliance with the requirements of 5.1.1 and 5.1.2, including the requirements of IEC 60228, shall be checked by inspection and by measurement.

5.1.4 Electrical resistance

For cables – other than tinsel cords – the resistance of each conductor at 20 °C shall be in accordance with the requirements of IEC 60228 for the given class of the conductor.

Compliance shall be checked by the test given in 2.1 of IEC 60227-2.

5.2 Insulation

5.2.1 Material

The insulation shall be polyvinyl chloride compound of the type specified for each type of cable in the particular specifications (see IEC 60227-3, IEC 60227-4, etc.).

Type PVC/C in the case of cables for fixed installation.

Type PVC/D in the case of flexible cables.

Type PVC/E in the case of heat-resistant cables for internal wiring.

The test requirements for these compounds are specified in table 1.

The maximum operating temperatures for cables insulated with any of the above types of compound and covered by the particular specifications (see IEC 60227-3, IEC 60227-4, etc.) are given in those publications.

5.2.2 Application to the conductor

The insulation shall be so applied that it fits closely on the conductor, but for cables other than tinsel cords, it shall be possible to remove it without damage to the insulation itself, to the conductor or to the tin coating if any. Compliance shall be checked by inspection and by manual test.

5.2.3 Thickness

The mean value of the thickness of insulation shall be not less than the specified value for each type and size of cable shown in the tables of the particular specifications (IEC 60227-3, IEC 60227-4, etc.).

However, the thickness at any place may be less than the specified value provided that the difference does not exceed 0,1 mm + 10 % of the specified value.

Compliance shall be checked by the test given in 1.9 of IEC 60227-2.

5.2.4 Mechanical properties before and after ageing

The insulation shall have adequate mechanical strength and elasticity within the temperature limits to which it may be exposed in normal use.

Compliance shall be checked by carrying out the tests specified in table 1.

The applicable test methods and the results to be obtained are specified in table 1.

Table 1 – Requirements for the non-electrical tests for polyvinyl chloride (PVC) insulation

1	2	3	4	5	6	7	
Reference No.	Test	Unit	Type of component			Test method described in	
			PVC/C	PVC/D	PVC/E	IEC	subclause
1	<i>Tensile strength and elongation at break</i>					60811-1-1	9.1
1.1	Properties in the state as delivered						
1.1.1	Values to be obtained for the tensile strength: – median, min.	N/mm ²	12,5	10,0	15,0		
1.1.2	Values to be obtained for the elongation at break: – median, min.	%	125	150	150		
1.2	Properties after ageing in air oven					60811-1-2 and 60811-1-1	8.1.3.1 and 9.1
1.2.1	Ageing conditions: – temperature – duration of treatment	°C h	80 ± 2 7 × 24	80 ± 2 7 × 24	135 ± 2 10 × 24		
1.2.2	Values to be obtained for the tensile strength: – median, min. – variation ¹⁾ , max.	N/mm ² %	12,5 ±20	10,0 ±20	15,0 ±25		
1.2.3	Values to be obtained for the elongation at break: – median, min. – variation ¹⁾ , max.	% %	125 ±20	150 ±20	150 ±25		
2	<i>Loss of mass test</i>					60811-3-2	8.1
2.1	Ageing conditions: – temperature – duration of treatment	°C h	80 ± 2 7 × 24	80 ± 2 7 × 24	115 ± 2 10 × 24		
2.2	Values to be obtained for the loss of mass, max.	mg/cm ²	2,0	2,0	2,0		
3	<i>Compatibility test ²⁾</i>						
3.1	Ageing conditions	°C h	80 ± 2 7 × 24	80 ± 2 7 × 24	100 ± 2 10 × 24	60811-1-2	8.1.4
3.2	Mechanical properties after ageing Values to be obtained		As in references Nos. 1.2.2 and 1.2.3				
4	<i>Heat shock test</i>					60811-3-1	9.1
4.1	Test conditions: – temperature – duration of treatment	°C h	150 ± 2 1	150 ± 2 1	150 ± 2 1		
4.2	Results to be obtained		Absence of cracks				

¹⁾ Variation: difference between the median value after ageing and the median value without ageing, expressed as a percentage of the latter.

²⁾ If applicable, see 5.3.1.

Table 1 (*end*)

1	2	3	4	5	6	7	
Reference No.	Test	Unit	Type of component			Test method described in	
			PVC/C	PVC/D	PVC/E	IEC	subclause
5	<i>Pressure test at high temperature</i>					60811-3-1	8.1
5.1	Test conditions: – force exercised by the blade – duration of heating under load – temperature	See 8.1.4 of IEC 60811-3-1 See 8.1.5 of IEC 60811-3-1					
		°C	80 ± 2	70 ± 2	90 ± 2		
5.2	Results to be obtained: – median of the depth of penetration, max.	%	50	50	50		
6	<i>Bending test at low temperature</i>					60811-1-4	8.1
6.1	Test conditions: – temperature ¹⁾ – period of application of low temperature	See 8.1.4 and 8.1.5 of IEC 60811-1-4					
		°C	–15 ± 2	–15 ± 2	–15 ± 2		
6.2	Results to be obtained		Absence of cracks				
7	<i>Elongation test at low temperature</i>					60811-1-4	8.3
7.1	Test conditions: – temperature ¹⁾ – period of application of low temperature	See 8.3.4 and 8.3.5 of IEC 60811-1-4					
		°C	–15 ± 2	–15 ± 2	–		
7.2	Result to be obtained: – elongation without break, min.	%	20	20	–		
8	<i>Impact test at low temperature ²⁾</i>					60811-1-4	8.5
8.1	Test conditions: – temperature ¹⁾ – period of application of low temperature – mass of hammer	See 8.5.5 of IEC 60811-1-4					
		°C	–15 ± 2	–15 ± 2	–		
8.2	Results to be obtained	See 8.5.6 of IEC 60811-1-4					
9	<i>Thermal stability test</i>					60811-3-2	9
9.1	Test conditions: – temperature	°C	–	–	200 ± 0,5		
9.2	Result to be obtained: – mean value of the thermal stability time, min.	min	–	–	180		

¹⁾ Due to climatic conditions, national standards may require a lower test temperature to be used.

²⁾ If specified in the particular specifications (IEC 60227-3, IEC 60227-4, etc.).

5.3 Filler

5.3.1 Material

Unless otherwise specified in the particular specifications (IEC 60227-3, IEC 60227-4, etc.), the fillers shall be composed of one of the following or of any combination of the following:

- a compound based on unvulcanized rubber or plastics; or
- natural or synthetic textiles; or
- paper.

When the filler is composed of unvulcanized rubber, there shall be no harmful interactions between its constituents and the insulation and/or the sheath. Compliance with this requirement shall be checked by the test given in 8.1.4 of IEC 60811-1-2.

5.3.2 Application

For each type of cable, the particular specifications (IEC 60227-3, IEC 60227-4, etc.) specify whether that cable includes fillers or whether the sheath or inner covering may penetrate between the cores, thus forming a filling.

The fillers shall fill the spaces between the cores giving the assembly a practically circular shape. The fillers shall not adhere to the cores. The assembly of cores and fillers may be held together by a film or tape.

5.4 Extruded inner covering

5.4.1 Material

Unless otherwise specified in the particular specifications (IEC 60227-4, etc.), the extruded inner covering shall be composed of a compound based on unvulcanized rubber or plastics.

Where the inner covering is composed of unvulcanized rubber, there shall be no harmful interactions between its constituents and the insulation and/or the sheath.

Compliance with this requirement shall be checked by the test given in 8.1.4 of IEC 60811-1-2.

5.4.2 Application

The extruded inner covering shall surround the cores and may penetrate the spaces between them giving the assembly a practical circular shape. The extruded inner covering shall not adhere to the cores.

For each type of cable, the particular specifications (IEC 60227-4, etc.) indicate whether that cable includes an extruded inner covering or not, or whether the outer sheath may penetrate between the cores, thus forming a filling.

5.4.3 Thickness

Unless otherwise specified in the particular specifications (IEC 60227-4, etc.), no measurement is required for the extruded inner covering.

5.5 Sheath

5.5.1 Material

The sheath shall be polyvinyl chloride compound of the type specified for each type of cable in the particular specifications (see IEC 60227-4, etc.):

- type PVC/ST4 in the case of cables for fixed installations;
- type PVC/ST5 in the case of flexible cables;
- type PVC/ST10 in the case of cables sheathed with a 90° polyvinyl chloride compound.

The test requirements for these compounds are specified in table 2.

5.5.2 Application

The sheath shall be extruded in a single layer:

- a) on the core, in the case of single-core cables;
- b) on the assembly of cores and fillers or inner covering, if any, in the case of other cables.

The sheath shall not adhere to the cores. A separator, consisting of a film or tape, may be placed under the sheath.

In certain cases, indicated in the particular specifications (IEC 60227-4, etc.), the sheath may penetrate into the spaces between the cores, thus forming a filling (see 5.4.2).

5.5.3 Thickness

The mean value of the thickness shall not be less than the specified value for each type and size of cable shown in the tables of the particular specifications (IEC 60227-4, etc.).

However, the thickness at any place may be less than the specified value provided that the difference does not exceed 0,1 mm + 15 % of the specified value, unless otherwise specified.

Compliance shall be checked by the test given in 1.10 of IEC 60227-2.

5.5.4 Mechanical properties before and after ageing

The sheath shall have adequate mechanical strength and elasticity within the temperature limits to which it may be exposed in normal use.

Compliance shall be checked by carrying out the tests specified in table 2.

The applicable test values and the results to be obtained are specified in table 2.

Table 2 – Requirements for the non-electrical test for polyvinyl chloride (PVC) sheaths

1	2	3	4	5	6	7	8	
Reference No.	Test	Unit	Type of compound				Test method described in	
			PVC/ST4	PVC/ST5	PVC/ST9	PVC/ST10	IEC	clause/subclause
1	<i>Tensile strength and elongation at break</i>						60811-1-1	9.2
1.1	Properties in the state as delivered							
1.1.1	Values to be obtained for the tensile strength:							
	– median, min.	N/mm ²	12,5	10,0	10,0	10,0		
1.1.2	Values to be obtained for the elongation at break:							
	– median, min.	%	125	150	150	150		
1.2	Properties after ageing in the air oven						60811-1-2	8.1
1.2.1	Ageing conditions:						60811-1-1	9.2
	– temperature	°C	80 ± 2	80 ± 2	80 ± 2	135 ± 2		
	– duration of treatment	h	7 × 24	7 × 24	7 × 24	10 × 24		
1.2.2	Values to be obtained for the tensile strength:							
	– median, min.	N/mm ²	12,5	10,0	10,0	10,0		
	– variation ¹⁾ , max.	%	±20	±20	±20	±25		
1.2.3	Values to be obtained for the elongation at break:							
	– median, min.	%	125	150	150	150		
	– variation ¹⁾ , max.	%	±20	±20	±20	±25		
2	<i>Loss of mass test</i>						60811-3-2	8.2
2.1	Ageing conditions:							
	– temperature	°C	As in reference No. 1.2.1			115 ± 2		
	– duration of treatment	h				10 × 24		
2.2	Values to be obtained for the loss of mass, max.	mg/cm ²	2,0	2,0	2,0	2,0		
3	<i>Compatibility test ²⁾</i>						60811-1-2	8.1.4
3.1	Ageing conditions:							
	– temperature	°C	As in reference No. 1.2.1			100 ± 2		
	– duration of treatment	h				10 × 24		
3.2	Mechanical properties after ageing		As in references Nos. 1.2.2 and 1.2.3					
	Values to be obtained							
4	<i>Heat shock test</i>						60811-3-1	9.2
4.1	Test conditions:							
	– temperature	°C	150 ± 2	150 ± 2	150 ± 2	150 ± 2		
	– duration of treatment	h	1	1	1	1		
4.2	Result to be obtained		Absence of cracks					

¹⁾ Variation: difference between the median value after ageing and the median value without ageing, expressed as a percentage of the latter.

²⁾ Only applicable when called up by the particular cable standard, see also 5.3.1.

Table 2 (concluded)

1	2	3	4	5	6	7	8	
Reference No.	Test	Unit	Type of compound				Test method described in	
			PVC/ST4	PVC/ST5	PVC/ST9	PVC/ST10	IEC	clause/subclause
5	<i>Pressure test at high temperature</i>						60811-3-1	8.2
5.1	Test conditions: – force exercised by the blade – duration of heating under load – temperature	h °C	80 ± 2	70 ± 2	70 ± 2	90 ± 2	60811-3-1 60811-3-1	8.2.4 8.2.5
5.2	Results to be obtained: – median of the depth of penetration, max.	%	50	50	50	50		
6	<i>Bending test at low temperature</i>						60811-1-4	8.2
6.1	Test conditions: – temperature ¹⁾ – period of application of low temperature	°C h	–15 ± 2	–15 ± 2	–15 ± 2	–15 ± 2	60811-1-4	8.2.3
6.2	Results to be obtained		Absence of cracks					
7	<i>Elongation test at low temperature</i>						60811-1-4	8.4
7.1	Test conditions: – temperature ¹⁾ – period of application of low temperature	°C h	–15 ± 2	–15 ± 2	–15 ± 2	–15 ± 2	60811-1-4	8.4.4 and 8.4.5
7.2	Result to be obtained: – elongation without break, min.	%	20	20	20	20		
8	<i>Impact test at low temperature</i>						60811-1-4	8.5
8.1	Test conditions: – temperature ¹⁾ – period of application of low temperature – mass of hammer	°C h	–15 ± 2	–15 ± 2	–15 ± 2	–15 ± 2	60811-1-4 60811-1-4 60811-1-4 60811-2-1	8.5.5 8.5.4 8.5.6 10
8.2	Result to be obtained							
9	<i>Mechanical properties after immersion in mineral oil</i>							
9.1	Test conditions: – temperature of oil – duration of immersion in oil	°C h	– –	– –	90 ± 2 24	– –		
9.1.1	Value to be obtained for the tensile strength: – variation max. ²⁾	%	–	–	±30	–		
9.1.2	Value to be obtained for the elongation at break: ²⁾ – variation max.	%	–	–	±30	–		
10	<i>Minimum thermal stability at 200 °C</i>	min	–	–	–	180	60811-3-2	9

¹⁾ Due to climatic conditions, national standards may require the use of a lower test temperature.
²⁾ Variation is the difference between the median value after ageing and the median value without ageing, expressed as a percentage of the latter.

5.6 Tests on completed cables

5.6.1 Electrical properties

The cables shall have adequate dielectric strength and insulation resistance.

Compliance shall be checked by carrying out the tests specified in table 3.

The test methods and the results to be obtained are specified in table 3.

Tableau 3 – Requirements for electrical tests for PVC insulated cables

1	2	3	4	5	6	7	
Reference No.	Test	Unit	Rated voltage of cables			Test method described in	
			300/ 300 V	300/ 500 V	450/ 750 V	IEC	subclause
1	<i>Measurement of the resistance of conductors</i>					60227-2	2.1
1.1	Values to be obtained, max.		See IEC 60228 and particular specifications (IEC 60227-3, IEC 60227-4, etc.)				
2	<i>Voltage test on completed cables</i>					60227-2	2.2
2.1	Test conditions: – minimum length of the sample – minimum period of immersion in water – temperature of the water	m h °C	10 1 20 ± 5	10 1 20 ± 5	10 1 20 ± 5		
2.2	Voltage applied (a.c.)	V	2 000	2 000	2 500		
2.3	Duration of each application of voltage, min.	min	5	5	5		
2.4	Results to be obtained		No breakdown				
3	<i>Voltage test on cores</i>					60227-2	2.3
3.1	Test conditions: – length of sample – minimum period of immersion in water – temperature of the water	m h °C	5 1 20 ± 5	5 1 20 ± 5	5 1 20 ± 5		
3.2	Applied voltage (a.c.) according to specified thickness of insulation: – up to and including 0,6 mm – exceeding 0,6 mm	V V	1 500 2 000	1 500 2 000	– 2 500		
3.3	Duration of each application of voltage, min.	min	5	5	5		
3.4	Results to be obtained		No breakdown				
4	<i>Measurement of insulation resistance</i>					60227-2	2.4
4.1	Test conditions: – length of sample – previous voltage test as in Ref. Nos. 2 or 3 – minimum period of immersion in hot water – temperature of water	m h	5 2	5 2	5 2		
4.2	Results to be obtained		See tables in the particular specifications (IEC 60227-3, IEC 60227-4, etc.)				

5.6.2 Overall dimensions

The mean overall dimensions of the cables shall be within the limits specified in the tables in the particular specifications (see IEC 60227-3, IEC 60227-4, etc.).

The difference between any two values of the overall diameter of sheathed circular cables of the same cross-section (ovality) shall not exceed 15 % of the upper limit specified for the mean overall diameter.

Compliance shall be checked by the tests given in 1.11 of IEC 60227-2.

5.6.3 Mechanical strength of flexible cables

The flexible cables shall be capable of withstanding bending and other mechanical stresses occurring in normal use.

When specified in the particular specifications (see IEC 60227-5, etc.), compliance shall be checked by the test given in clause 3 of IEC 60227-2.

5.6.3.1 Flexing test for flexible cables

See 3.1 of IEC 60227-2.

During the test with 15 000 backward and forward movements, i.e. 30 000 single strokes, neither interruption of the current nor short circuit between the conductors shall occur.

After the test, the sample shall withstand the voltage test carried out in accordance with 2.2 of IEC 60227-2.

5.6.3.2 Bending test for tinsel cord

See 3.2 of IEC 60227-2.

During the test with 60 000 bending cycles, i.e. 120 000 single strokes, interruption of the current shall not occur.

After the test, the sample shall withstand the voltage test carried out in accordance with 2.2 of IEC 60227-2, the voltage, however, being 1 500 V and applied only between the conductors connected together and the water.

5.6.3.3 Snatch test for tinsel cord

See 3.3 of IEC 60227-2.

During the test, interruption of the current shall not occur.

5.6.3.4 Test for separation of cores

See 3.4 of IEC 60227-2.

The force shall be between 3 N and 30 N.

5.6.4 Flame retardance

All the cables shall comply with the test specified in IEC 60332-1.

6 Guide to use of the cables

Under consideration.

Annex A (normative)

Code designation

Cables of the types covered by this standard are designated by two numerals, preceded by the reference number of this standard.

The first numeral indicates the basic class of cable; the second numeral indicates the particular type within the basic class.

The classes and types are as follows:

- 0. Non-sheathed cables for fixed wiring.
 - 01. Single-core non-sheathed cable with rigid conductor for general purposes (60227 IEC 01).
 - 02. Single-core non-sheathed cable with flexible conductor for general purposes (60227 IEC 02).
 - 05. Single-core non-sheathed cable with solid conductor for internal wiring for a conductor temperature of 70 °C (60227 IEC 05).
 - 06. Single-core non-sheathed cable with flexible conductor for internal wiring for a conductor temperature of 70 °C (60227 IEC 06).
 - 07. Single-core non-sheathed cable with solid conductor for internal wiring for a conductor temperature of 90 °C (60227 IEC 07).
 - 08. Single-core non-sheathed cable with flexible conductor for internal wiring for a conductor temperature of 90 °C (60227 IEC 08).
- 1. Sheathed cables for fixed wiring.
 - 10. Light polyvinyl chloride sheathed cable (60227 IEC 10).
- 4. Non-sheathed flexible cables for light duty.
 - 41. Flat tinsel cord (60227 IEC 41).
 - 42. Flat non-sheathed cord (60227 IEC 42).
 - 43. Cord for decorative chains (60227 IEC 43).
- 5. Sheathed flexible cables for normal duty.
 - 52. Light polyvinyl chloride sheathed cord (60227 IEC 52).
 - 53. Ordinary polyvinyl chloride sheathed cord (60227 IEC 53).
- 7. Sheathed flexible cables for special duty.
 - 71c Circular polyvinyl chloride sheathed lift cable and cable for flexible connections (60227 IEC 71c).
 - 71f Flat polyvinyl chloride sheathed lift cables and cables for flexible connections (60227 IEC 71f).

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